REQUIREMENTS ON QUALIFICATION, COMPETENCE AND SUFFICIENT NUMBER OF PERSONNEL FOR NPP OPERATION

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ABSTRACT

The safe operation of NPPs presupposes qualified personnel on-site in sufficient numbers. While the acquisition and preservation of technical expertise and the qualification of the shift personnel and other staff is well regulated by regulatory guidelines in Germany, there is a lack of such regulations – with the exception for shift personnel - for the minimum number of technical personnel required for safe operation of an NPP.

By order of the BMU, an attempt was made with this study to work out the requirements for qualification, competence and number of personnel to be maintained at the plant, representing the minimum requirements for safe operation of an NPP. The scope of the project was restricted to requirements for technical plant personnel. The aim was to work out requirements which would be as independent as possible of the existing organisation in a particular power plant. This study therefore does not assume a given organisational structure but was rather more oriented on the work processes in an NPP which are the basis for planning and performing routine work in the plant.

For the study a work process modell of typical tasks in an NPP had to be developed. Then, the tasks to be performed within the work processes were defined (task profiles) on the basis of existing descriptions of the plant organisation. From these task profiles such tasks were selected which shall not be delegated to external personnel; these were called vital competences. To keep these vital competences at the plant, an assessment or calculation of the necessary number of plant technical personnel was made by using the task profiles for “responsible” staff, but also by the evaluation of thousands of work orders for maintenance personnel.

On the basis of these data, a proposal was made for the minimum number of technical personnel which is necessary to operate an NPP unit safely. Beside of this number, general criteria were developed which should be fulfilled to keep competent staff and a sufficient number of plant personnel on-site. Criteria were also developed to define the borderline for the employment of plant external personnel and contractors.

1 INTRODUCTION

The safe operation of NPPs presupposes qualified and competent personnel in sufficient numbers. While the acquisition and preservation of technical expertise and the qualification of the shift personnel and other staff are well regulated in regulatory guidelines in Germany, there is a lack of such regulations -with the exception of those for shift personnel- for the minimum number of technical personnel required for the safe operation of an NPP. According to existing regulations, the German NPP operators are requested to present “orientation” numbers for the “responsible” and “other” personnel in their operating organization, but there is no regulation which would force them to respect minimum limits for this staff. Beside a sufficient number of personnel, their qualification and competence is also an important prerequisite for safe plant operation.

Concerned by recent efforts to reduce the costs of plant operation, the licensing authorities asked the German ministry responsible to advise them on how to react on such developments. By order of the ministry, BMU, a study was performed to define requirements for the qualification, competence and numbers of personnel to be maintained at the plant, representing the minimum requirements for the safe operation of an NPP. The scope of the study was restricted to requirements for technical plant personnel.

2 QUALIFICATION OF PLANT PERSONNEL

For the assessment of the necessary qualification and competence of plant personnel, the existing regulatory framework was used, in particular the German ordinance for the certification of "responsible" personnel (including shift personnel) and the ordinance for establishing the necessary knowledge of "other" plant personnel. The findings were that the regulations for certification and proof of knowledge of plant personnel are well developed in Germany. Therefore it is not deemed necessary to propose any additional requirements in this field. But one point was found to be missing. In German regulations, no requirements exist for organizational issues, e.g. long term staffing plan, safety policy, safety management. Such self-commitment on the part of the operating organization should exist and should be periodically checked by the authority.

3 WORK PROCEDURES

Two important ordinances have to be considered for planning and carrying out maintenance work in German NPPs:

- the radiation protection ordinance and
- the maintenance ordinance.

Both procedures are related to maintenance work and plant modifications. Both ordinances, which were issued by the licensing authority, also include flow diagrams which prescribe the preparation of the work, the persons to be involved in the work, industrial safety measures, local work arrangements, and final testing. On the basis of these general ordinances, the NPPs have developed their own plant specific step-by-step procedures for carrying out maintenance work. Again, the procedures describe the complete chain of the work and the responsible persons involved, but no criteria exist for the necessary number of employees in the maintenance departments.

4 WORK PROCESS MODEL

One aim of the study was to work out requirements which would be as independent as possible from the existing organization in a particular power plant. The study therefore did not assume a given organizational structure, but was rather more oriented on the work processes in an NPP which are the basis for planning and performing routine work in the plant. The work process model, which describes the fundamental work processes, has been originally used for the development of indicators in the field of safety management and safety culture. Because general requirements for competence and numbers of personnel had to be developed in the study, it seemed to make sense to refer to work processes and not to different organizational structures. In Germany, different models for plant organizations exist like PUTI (Production, Support, Technique, Inspection), PUME (Production, Support, Mechanics, Electrics), and variations of them, which would have complicated the study unnecessarily. The following work processes were defined:

- The processes of plant operation. These processes include shift change, control room work, plant walk downs, plant supervision (i.e. radiation protection, chemistry, and physics).
- The support processes. These processes include documentation, experience feedback, training of personnel, management of spare parts.
- The processes of work preparation. These processes include failure identification, planning of plant modifications, and planning of inspections and tests.
- The processes of maintenance and repair. These processes include recurrent tests, in-service inspection, maintenance, repair, and the measures for radiological and industrial safety.
- The processes of quality management. These processes include quality planning and quality supervision.

Table 1 Work Processes

Plant Operation	**Support Processes**	**Work Preparation**	**Maintenance and repair**	***Quality Management***
Shift change	Documentation	Identification of failure	Maintenance, inspection, repair	*Quality planning*
Control room work	Experience feedback	Planning of modification	Recurrent testing	*Quality supervision*
Plant walk down	Training of personnel	In-service inspection planning	Radiological + industrial safety	
Plant supervision	*Spare parts*	*Planning of tests*		

The basis for the investigation was a single unit NPP of the PWR type. For the study, the following approach was used. As a starting point, the tasks within the so defined work processes were described in detail. With this regard, the chapters "plant organization" and shift organization" of the "manual for plant operation" were very helpful. In these chapters, task descriptions exist and responsibilities for the tasks are defined for all organizational units that belong to the different technical departments of the plant. In general, the technical departments are as follows: production, support, technical matters, and maintenance. Fortunately, it was possible to relate the task descriptions and responsibilities to most of the processes of the process model. An example is given in figure 1.

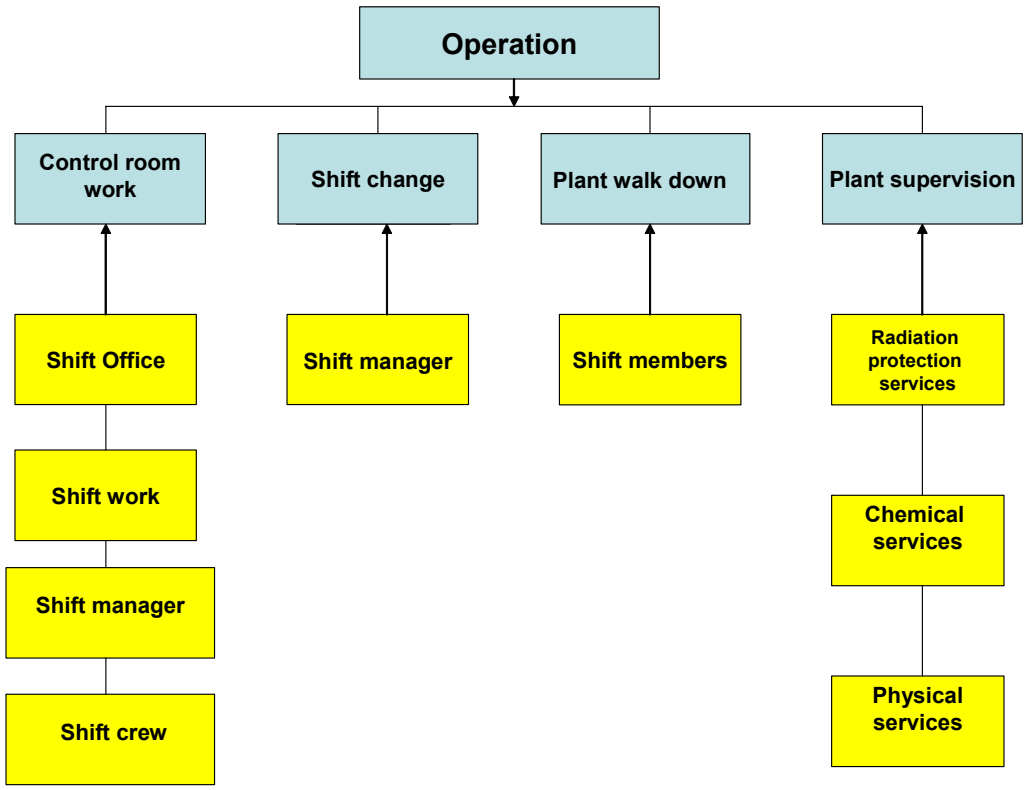

Figure 1: Example of relation of tasks and responsible personnel to work processes of "Plant Operation"

5 VITAL TASKS

It was very clear that the justification of how many technical personnel must be available at the plant all the time would strongly depend on the definition of the work to be done by these persons. For the definition, the term "vital tasks" was introduced. For the decision which tasks are "vital tasks" (which means that they shall not be performed by plant external personnel), the following definition was set up: Vital tasks are those tasks which shall not be delegated for safety reasons or because of existing laws, ordinances, and regulations. For the justification of the decision of how many persons must be available on-site, the following procedure was used:

- to describe the tasks within each work process as detailed and precisely as possible,
- based on these descriptions, to decide which tasks are "vital" tasks,
- to define those tasks which can be performed by other personnel (e.g. off-site or on-site contractors, staff at the headquarters)
- and finally, to create a method or methods for assessing the manpower to perform the vital tasks.

Examples of tasks which must be performed by plant personnel are:

- all shift work,
- radiological supervision of structures, systems, and components (SSC) and of maintenance work at SSC.
- chemical treatment of systems and components,
- planning, preparation, and supervision of maintenance work or plant modifications,
- operating experience feedback,
- documentation of plant operation.

Examples of tasks which need not be performed by plant personnel are:

- water and waste processing,
- radiological supervision of plant personnel,
- fuel handling,
- fuel management,
- storage of spare parts,
- decontamination work,
- housekeeping.

6 METHODS FOR THE ASSESSMENT

In principle, different methods can be used to assess the necessary number of plant personnel. One method may be purely descriptive, another may be based on data. For the work processes of

- plant operation,
- support,
- quality management,

no data or documents were available to calculate the annual working hours related to these processes, which - as a rule - are performed by engineers and technicians, who do not document their working hours by using work orders or time sheets. Therefore, the assessment of the necessary personnel was made on the basis of the descriptions of vital tasks within the work processes, considering also their scope, complexity, and required time availability. As the justification of the staff numbers was mainly based on engineering judgment, this assessment was made by persons having some knowledge and experience with NPP operation. The assessment of the necessary personnel for the processes of

- work preparation,
- in-service inspection, testing, maintenance, repairs

was done by the evaluation of thousands of work orders of a reference NPP. For these tasks, work orders are issued with the purpose of planning, performing, and final control of the work. The number of personnel for the tasks associated with these processes was calculated on the basis of the documented work orders.

Work orders contain the necessary data about the kind of work, the duration of work, the initiator for the work, and the departments involved in the work. For the maintenance work, GRS obtained a data file from

the reference plant. The file contained the work orders for on-site plant personnel per month over a time period of 11 years. The following two charts show the distribution of work orders over time for two departments. The time periods of plant shutdown for refueling are virtually marked with a pattern.

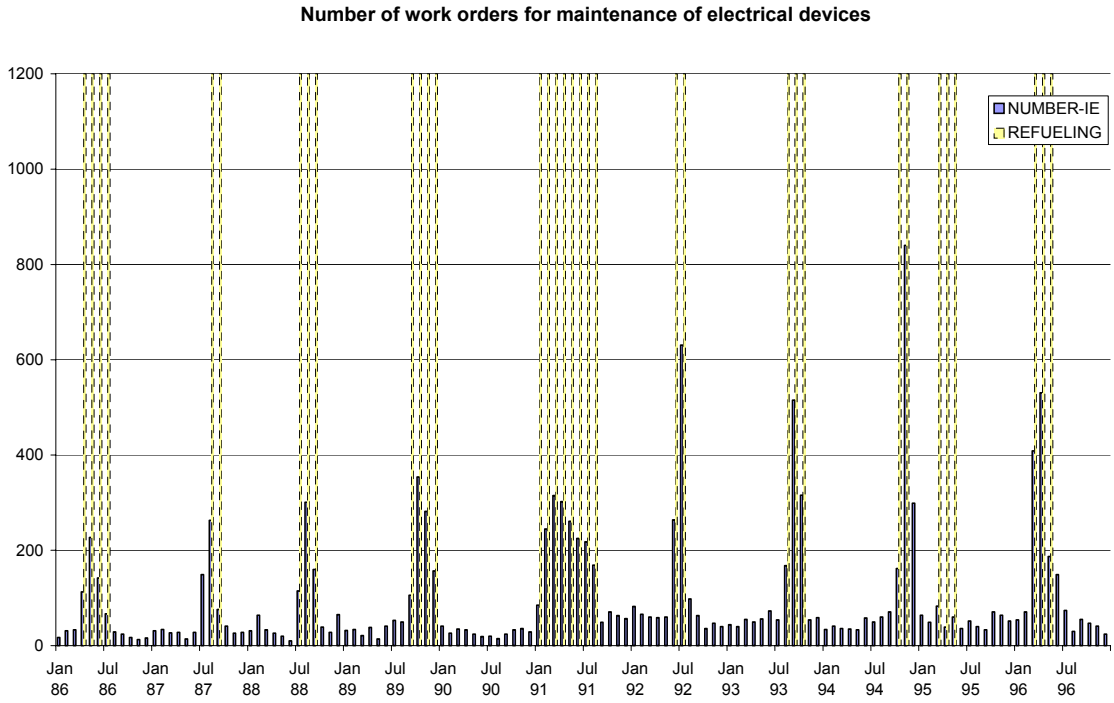

Figure 2 Number of work orders over time for the "Electrical Devices" department

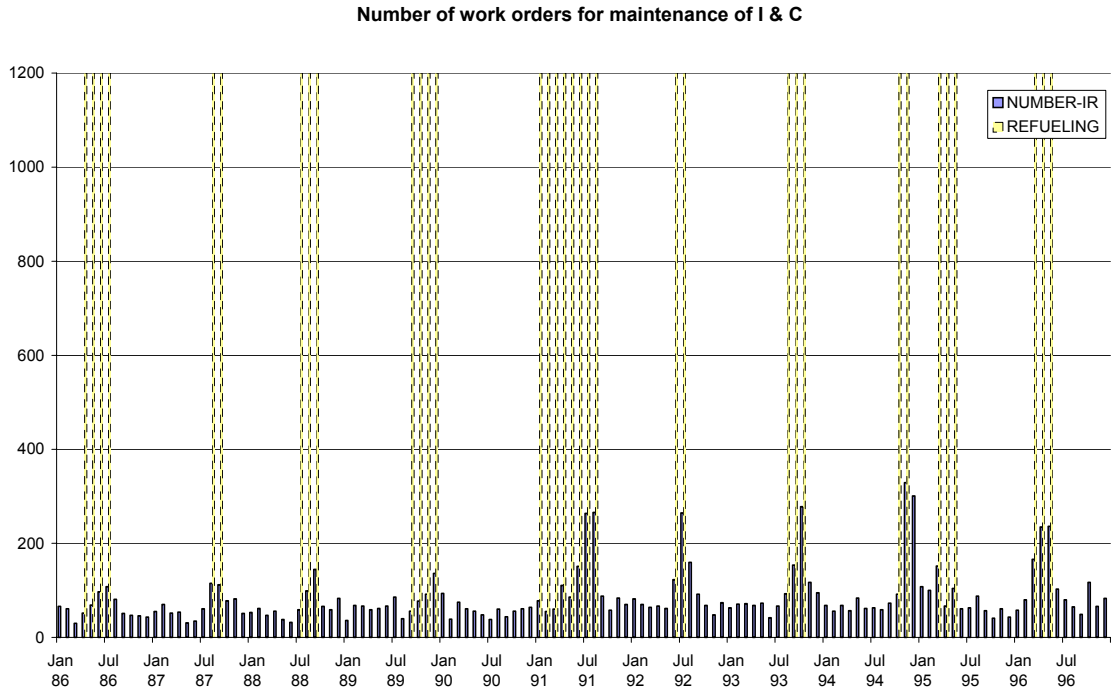

Figure 3 Number of work orders over time for the "I & C" department

By using these data it was possible to count the number of work orders per month, to correlate them with the working time, and to calculate the work load for the maintenance personnel of different departments

(Mechanical Devices, Mechanical Machines, Electrical Devices, I&C) separately for the period during normal operation and the period during refueling. From the work load in hours, the number of personnel in the maintenance area was derived. From the results it can be seen that a much higher number of maintenance personnel is necessary for preparing and performing work during refueling than for maintenance work during normal operation (Figure 4). This is not surprising, as the highest work load exists during plant outages. But it means that the plant operator is forced to keep a sufficient number of qualified employees on-site all year long; if not, he has to accept longer plant outage times.

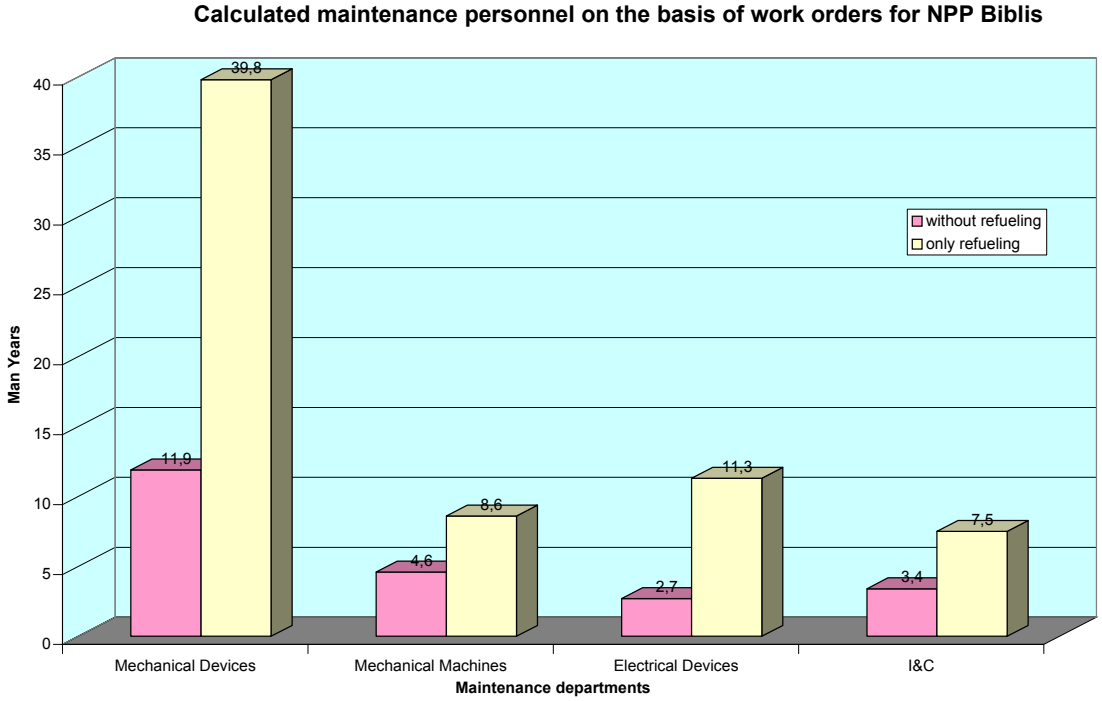

Figure 4 Required maintenance personnel during normal operation and during refueling

7 CONTRACTORS

There is an increasing tendency by plant operators to contract plant external personnel for services like performing in-service inspections or planning and carrying out parts of the refueling outage for economic reasons. But limitations and conditions exist for the kind and scope of work that can be delegated to contractors. Such restrictions are enforced by law or exist for safety reasons. In Germany, restrictions enforced by law are:

- the licensee is responsible for the operation of the plant,
- the licensee is responsible for the management of the plant.

Restrictions because of safety reasons are:

- the staff is responsible for the safe operation of the plant and the control of accidents,
- the staff is responsible for the status of systems and components,
- the staff is responsible for the analysis of disturbances in the plant,
- the staff is responsible for emergency situations,
- the staff must provide guidance to and supervision of contractors.

8 OPTIMIZATION

Because of the pressure to reduce the costs of plant operation, solutions also have been sought to reduce manual work with the help of advanced techniques. The largest potential to reduce manpower is seen in the area of maintenance. In recent years developments have started to optimize maintenance. This can be done by an introduction of new maintenance strategies, e.g. status oriented maintenance instead of preventive

maintenance, on-line supervision of components instead of inspection, use of automatic devices for inspections of components instead of manual inspections, maintenance during power operation instead of during refueling, and the modification of maintenance intervals. All these measures together will reduce the workload on maintenance personnel. However, as these developments are not new, but have already been implemented in the plants, no credit has been given in this study for a possible further reduction of maintenance personnel.

9 GENERAL REQUIREMENTS TO ASSURE SUFFICIENT COMPETENCE AND MANPOWER

During the study it was found that it would be difficult to define a minimum number for on-site plant personnel, because this number could vary with the plant type, number of units, number of plant external personnel, and number of service personnel working at headquarters. Therefore, additional, more general requirements were defined for the processes and tasks to assure that the utilities have sufficient competent personnel and a sufficient number of personnel on site.

10 RESULTS OF THE STUDY

For the verification of the assessed and/or calculated numbers of technical plant personnel, the results were discussed with the plant management of three NPPs (two PWR and BWR), each of them having a different structure of plant organization, and were compared with the numbers of employees at each site. The main steps were: comparison of calculated and actual personnel for the different work processes, discussion of deviations, and correction of numbers, if necessary.

As a result of the study it was shown that for the safe operation of a single unit, 270 qualified persons must be available on site for fulfilling accurately and in time the defined tasks within the different work processes. This number also includes management staff.

The following numbers for technical personnel were derived:

- 105 persons for the processes of plant operation, including the sub-processes operation (shifts, shift office) and plant supervision (radiological protection, chemistry, physics),
- 113 persons for the processes of preventive maintenance, including the sub-processes maintenance planning, plant modifications, execution of maintenance, work safety),
- 21 persons for the support processes, including the sub-processes training, experience feedback, data processing, documentation, reporting,
- 3 persons for the process of quality management,
- an additional 28 persons for management tasks.

Table 2 Required personnel for the work processes

Plant Operation		**Support Processes**		**Preparation of Maintenance**		**Preventive Maintenance**		**Quality Management**	
shift work shift office	60 15	training	3	mechanical devices	16	mechanical work	45	quality planning and supervision	*3*
radiation protection	18	experience feedback	3	electrical devices	8	electrical work	10		
chemistry	10	data processing	6	electronics	16	electronics	15		
physics	2	documentation + reporting	9	materials, non-destructive testing	3				
managers									*28*
SUM	105		43		70		21		*31*
SUM									*270*

As the organization of the plant is not work process oriented, but structured in departments and divisions, an organization chart for a ficticious unit was filled with these data (like a translation of the data for the work processes into data for the organization). However, as a specific task in a work process is not necessarily bound to a specific organizational structure, deviations may exist for the numbers of persons in the different departments in a real plant. Nevertheless, the overall number of persons (270) should not be delimited.

Table 3 Number of necessary technical personnel for a "real" PWR

NPP	**Production**		**Supervision**		**Central Services**		**Mechanical**		**Electrical**		**I&C**		**Maintenance**	
							Engineering		**Engineering**					
	Shifts	60	**Radioprotection**	18	**Training**	3	**Systems**	8	**Electrical systems**	4	**Reactor protection,**	4	**Mech. Maintenance**	45
	Shift 1		protection...				**... nuclear**				**ESFAS electr. Part**		work preparation	
	Shift 2		....measures		**Experience ...**	3	**Systems**	8	**Electrical**	4			mech. workshop	
	Shift 3		radioactive waste		**....feedback**		**..conventionel**		**machines**		**Conventional I&C**	4	manufactoring	
	Shift 4		site specific work		**Data processing**	6								
	Shift 5				Information systems		**Materials,**	3			**Nuclear I&C**	4	**Elect. Maintenance**	10
	Shift n		**Chemistry**	10	**Spare parts***	0	**non-destr.testing**						work preparation	
			Radiochemistry										electr. Workshop	
	Shift office	15	Water chemistry		**Documentation +**	9					**Computer technics**	4		
					Reporting						Process computer,		**I&C maintenance**	15
			Physics	2							Networks		work preparation	
			core physics		**Quality-**	3							I&C workshop	
			fuel elements		**control**									
	management	3		4		6		4		2		4		4
	Head of plant	1												
Sum 1		79		34		30		23		10		20		74

*no vital competence

Sum 2 270

11 RESPONSE TO THE STUDY

The report of the study was distributed to all plant operators, licensing authorities, and Technical Support Organizations. The report was appreciated by the authorities and also by plant operators. Because of existing regulations in Germany, each modification of plant organization must be approved by the authority of the state where the plant was licensed. GRS recommended in its report that a reduction of staff below the proposed number for technical personnel must be justified by the licensee and accepted by the regulatory body.